MH 2300 Functional materials 6 hp

Aim
To gain deep knowledge about materials which are not primarily used for their mechanical properties, but for other properties such as physical, chemical, *etc.* To know what "functions" can be built into the materials and how to maximise their performance.

Learning objectives. After passing the course the student should be able to:

LO1. Describe the properties of various functional materials and formulate models of the underlying physical and chemical phenomena.
LO2. Indicate the most important properties of functional materials including availability, price, manufacturing capacity, durability, recyclability and environmental impact. Compare different materials according to these properties.
LO3. Search and critically analyze literature data on the properties of functional materials.
LO4. Rationally select functional materials for existing and new applications.

Syllabus
Specific properties of functional materials are covered, which are used in high-tech applications. The course includes:

- Intermetallic materials including
  - superalloys
  - shape memory alloys
  - coating materials
- Biomaterials
- Advanced ceramics, including
  - ferroelectric and piezoelectric materials
  - insulating materials
  - thermal barrier coatings
- Magnetic materials
- Electronic materials, including
  - elemental and compound semiconductors
  - conductive polymers
  - ionic conductors
- Catalytic materials

Pre-requisites

Basic knowledge in materials science corresponding to the course MH1024 Fundamentals of Materials Science - Metallic Materials.

Language
The course is given in English.

Teachers
Lectures and seminars: Pavel Korzhavyi, pavelk@kth.se, tel. 790 9193
Projects and guest lecture: Claudio Lousada, cmlp@kth.se, tel. 790 8789

Lectures (rooms at Brinellvägen 23), tentative

Date	Part	Room	Theme
Monday March 20, 10-12	I	M121(Blå)	Intermetallic materials I
Wednesday March 22, 08-10	I	B22	Intermetallic materials II
Monday March 27, 10-12	I	M121(Blå)	Advanced ceramics: Ferroelectrics I
Wednesday March 29, 08-10	I	M121(Blå)	Advanced ceramics: Ferroelectrics II
Wednesday April 5, 08-10	II	M121(Blå)	Magnetic materials
Monday April 17, 10-12	II	M121(Blå)	Shape memory alloys
Wednesday April 19, 08-10	II	M121(Blå)	Catalytic materials
Monday April 24, 10-12	II	M121(Blå)	Semiconductors I
Wednesday April 26, 08-10	II	M121(Blå)	Semiconductors II
Monday May 8, 09-12		M121(Blå)	Partial reporting of projects
Monday May 15, 09-12		M121(Blå)	Reporting of projects

Tests (kontrollskrivningar), tentative

On lectures part I: Monday April 3, 15:00-17:00, M121(Blå)

On lectures part II: Wednesday May 3, 15:00-17:00, M121(Blå)

Examination

For all students:

i) written report to be presented at the seminars (see special instructions)

ii) participation in seminars

iii) approved tests

Those who could not attend or pass tests I or II, may (re)write tests on the exam week,

Voluntarily examination: Wednesday May 31, 08:00-12:00, FP41.

Course literature

Compendium on Functional materials (excl. chapters 4 to 6 on biomaterials)

Distributed articles

Results of a literature search should be used for the preparation of the report.

Short layout of the reports to be written

- Register for a report topic as soon as possible
- Use the listed literature review as a starting point. Use Elsevier's Science Direct to search for more literature.
- Summarise the scientific knowledge about the chosen topic. Always use your own words, do never copy text.
- Summarise the potential industrial applications for materials or techniques covers. Describe how knowledge could be commercialised.
- When you use a specific source you should always give a reference at that point.
- The report should be written as educational material at your own level. Thus the material should be suitable for a forthcoming course. Figures should be placed in the text, each with a caption below it. Each table, also in the text should have a heading above it.
- The expected size of each report is 10 A4 pages per student with 1.5 p line spacing, Times New Roman, 12 p (~10 A4 pages per student)
- Follow the guidelines[1] for how to write scientific reports.

Schedule, tentative

Each group should present an **outline of the report** at the seminar on **Monday, May 8, 9:00-12:00, M121(Blå)**.

The final reports should be delivered strictly according to the schedule below in electronic form by email.

Presentation date	Report ready by	Send to
Monday May 15, 9-12, M121(Blå)	May 14, 15:00	cmlp@kth.se

[1] Writing scientific reports, R. Sandström, D. Andersson (MS&E, KTH, 2008).

Topics for Reports and Seminars (15 mins presentations by the students)

No	Theme	Name
1	Making sustainable aluminum by recycling scrap: The science of "dirty" alloys, *Progress in Materials Science*, Volume 128 (2022) Article 100947, M. Paolantonio, C. Liu, H. Antrekowitsch, *et al.*	
2	Multifunctional magneto-polymer matrix composites for electromagnetic interference suppression, sensors and actuators, *Progress in Materials Science*, Volume 115 (2021) Article 100705, A.D.M. Charles, A.N. Rider, S.A. Brown, C.H. Wang	
3	Self-assembly of perovskite nanocrystals, *Progress in Materials Science*, Volume 129 (2022) Article 100975, A. Jana, A. Meena, S.A. Patil, Y. Jo, S. Cho, Y. Park, V. Gopalan Sree, H. Kim, H. Im, R.A. Taylor	
4	Nucleation and growth in solution synthesis of nanostructures – From fundamentals to advanced applications, *Progress in Materials Science*, Volume 123 (2022) Article 100821, K.-J. Wu, E.C.M. Tse, C.x. Shang, Z.x. Guo	
5	Current development of materials science and engineering towards epidermal sensors, *Progress in Materials Science*, Volume 128 (2022) Article 100962, Sheng Zhang, Chen Liu, Xu Sun, Wenjing Huang	
6	High-entropy ceramics: Review of principles, production and applications, *Materials Science and Engineering R*, Volume 146 (2021) Article 100644, S. Akrami, P. Edalati, M. Fuji, K. Edalati	
7	Metal oxides based electrochemical pH sensors: Current progress and future perspectives, *Progress in Materials Science*, Volume 109 (2020) Article 100635, L. Manjakkal, D. Szwagierczak, R. Dahiya	
8	A review on recent applications and future prospects of rare earth oxides in corrosion and thermal barrier coatings, catalysts, tribological, and environmental sectors, *Ceramics International* (2022), https://doi.org/10.1016/j.ceramint.2022.07.220, M. Khalid Hossain, M.H.K. Rubel, M. Ali Akbar, *et al.*	

Two or three students write a report on their topic (annotated, about 10 pages/student).

No	Theme	Name
9	Sustainability through alloy design: Challenges and opportunities, *Progress in Materials Science*, Volume 117 (2021) Article 100722, J.L. Cann, A. De Luca, D.C. Dunand, *et al.*	
10	Manganese-based permanent magnet materials, *Progress in Materials Science*, Volume 124 (2022) Article 100872, T. Keller, I. Baker	
11	Advances of atomically dispersed catalysts from single-atom to clusters in energy storage and conversion applications, *Progress in Materials Science*, Volume 128 (2022), Article 100964, Y. Wang, X. Cui, J. Zhang, J. Qiao, H. Huang, J. Shi, G. Wang	
12	Direct observation of electric and magnetic fields of functional materials, *Materials Science & Engineering R*, Volume 142 (2020) Article 100564, D. Shindo, Z. Akase	
13	Coupling of mechanical deformation and electromagnetic fields in biological cells, *Reviews of Modern Physics*, Volume 94 (2022), Article 025003, M. Torbati, K. Mozaffari, L. Liu, P. Sharma	
14	Reactive oxygen nano-generators for cancer therapy, *Progress in Materials Science*, Volume 130 (2022), Article 100974, D. Kalyane, D. Choudhary, S. Polaka, H. Goykar, T. Karanwad, K. Rajpoot, R.K. Tekade	
15	High-electromechanical performance for high-power piezoelectric applications: Fundamental, progress, and perspective, *Progress in Materials Science*, Volume 127 (2022), Article 100944, L. Chen, H. Liu, H. Qi, J. Chen	
16	3D printed electronics: Processes, materials and future trends, *Progress in Materials Science*, Volume 127 (2022), Article 100945, H. W. Tan, Y.Y.C. Choong, C.N. Kuo, H.Y. Low, C.K. Chua	

Two or three students write a report on their topic (annotated, about 10 pages/student).

No	Theme	Name
17	Printing of flexible light emitting devices: A review on different technologies and devices, printing technologies and state-of-the-art applications and future prospects, *Progress in Materials Science*, Volume 118 (2021) Article 100760, I. Verboven, W. Deferme	
18	Additive manufacturing of biomaterials for bone tissue engineering – A critical review of the state of the art and new concepts, *Progress in Materials Science*, Volume 130 (2022) Article 100963, M.-M. Germaini, S. Belhabib, S. Guessasma, R. Deterre, P. Corre, P. Weiss	
19	Advanced ion transfer materials in electro-driven membrane processes for sustainable ion-resource extraction and recovery, *Progress in Materials Science*, Volume 128 (2022) Article 100958,	
20	Conducting polymer-based flexible thermoelectric materials and devices: From mechanisms to applications, *Progress in Materials Science*, Volume 121 (2021) Article 100840, S. Xu, X.-L. Shi, M. Dargusch, C. Di, J. Zou, Z.-G. Chen	
21	Transparent tellurite glass-ceramics for photonics applications: A comprehensive review on crystalline phases and crystallization mechanisms, *Progress in Materials Science*, Volume 125 (2022) Article 100890, P. Patra, K. Annapurna	
22	Negative thermal expansion in magnetic materials, *Progress in Materials Science*, Volume 121 (2021) Article 100835, Y. Song, N. Shi, S. Deng, X. Xing, J. Chen	

Two or three students write a report on their topic (annotated, about 10 pages/student).